

A POSSIBLE LUNAR INFLUENCE UPON THE VELOCITY OF THE WIND AT KIMBERLEY.

(FOURTH PAPER.)

BY J. R. SUTTON.

(With one Text-figure.)

The argument upon which the previous papers have been based is the almost axiomatic one that since the moon can raise an appreciable tide in the atmosphere it must also be able to create an appreciable wind. For there cannot be an air tide without an air movement. The wonder is that the question has not been tested before for various places lying between the temperate zones. But the expectation with which the inquiry was started, namely, that the air movement would be a direct function of the air tide, and hence show a simple small semi-diurnal oscillation of speed, has not been exactly verified. A variation of velocity depending on the hours of the lunar day has been found, but surprisingly large and of a special type, which would appear to be little more directly related to the air tide than the normal diurnal winds are to the normal diurnal pressures. The object of that portion of the inquiry with which this paper deals is to determine whether there are any points of agreement between the air tides and the lunar wind period sufficiently definite to form the nucleus of a theory which could be used to explain the comparatively great air speeds attributable to the moon's influence.

For this purpose the air-tidal variation at perigee and at apogee has been determined for ten years of observation, 1897 to 1906, as shown in Table I, using the hourly pressure deviations* from the monthly means for the day of perigee and of apogee, together with those for the day before and the day after. The period is shorter than that used for the wind, but since the air tides are fairly regular it is probably sufficiently long for the immediate purpose; and in any case the arithmetic involved is as much as my wife and I can undertake for the present. In order to avoid the use of minus signs the tabular quantities have all been augmented by one inch: thus, *e. g.* 1·0023 means + ·0023, and ·9950 means - ·0050.

* By Sabine's method, Phil. Trans., 1847.

In Table 1, column 1 shows the hour of the lunar day.

Column 2 the pressure variations at perigee when the moon's upper meridian passage (= U.M.P.) occurs within two hours of noon.

Column 3 the same for near midnight.

Column 4 the same when U.M.P. falls between II and X, and between XIV and XX ("Horizon").

Column 5 the mean of columns 2, 3, 4.

Column 6 the pressure variations at apogee.

Column 7 the mean of columns 5 and 6.

Column 8 is added to show the velocity deviations for perigee and apogee together. The quantities are taken from the second and third papers.

TABLE I.—Mean Hourly Air-Tidal Variation.

Hour.	Perigee P.				Apogee A.	$\frac{P + A}{2}$	Wind.
	Noon.	Midnight.	Horizon.	Mean.	Mean.		$\frac{P + A}{2}$
	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Mile.
L.M.P.	.9958	1.0055	1.0107	1.0043	.9952	.9997	10.039
II	.9966	1.0057	1.0106	1.0045	.9947	.9996	10.070
III	.9961	1.0052	1.0096	1.0038	.9936	.9987	10.058
IV	.9955	1.0043	1.0092	1.0032	.9932	.9980	10.001
V	.9950	1.0033	1.0078	1.0022	.9924	.9973	9.932
VI	.9953	1.0042	1.0075	1.0026	.9924	.9975	9.884
VII	.9957	1.0039	1.0083	1.0029	.9922	.9976	9.894
VIII	.9953	1.0037	1.0082	1.0026	.9918	.9972	9.927
IX	.9982	1.0040	1.0075	1.0034	.9921	.9977	9.949
X	.9987	1.0046	1.0075	1.0037	.9935	.9986	9.939
XI	.9998	1.0061	1.0078	1.0048	.9939	.9994	9.924
XII	1.0013	1.0052	1.0078	1.0049	.9946	.9997	9.910
U.M.P.	1.0023	1.0042	1.0066	1.0044	.9953	.9999	9.904
XIV	1.0.22	1.0036	1.0063	1.0041	.9954	.9997	9.920
XV	1.0017	1.0027	1.0041	1.0028	.9943	.9985	9.933
XVI	1.0015	1.0017	1.0030	1.0020	.9936	.9978	9.940
XVII	1.0008	1.0011	1.0022	1.0013	.9933	.9973	9.932
XVIII	.9994	1.0000	1.0028	1.0007	.9934	.9970	9.914
XIX	.9988	1.0002	1.0017	1.0003	.9935	.9969	9.908
XX	1.0018	.9995	1.0013	1.0008	.9936	.9972	9.904
XXI	1.0015	.9996	1.0008	1.0006	.9943	.9975	9.917
XXII	1.0019	1.0005	1.0001	1.0008	.9944	.9976	9.932
XXIII	1.0050	1.0018	.9995	1.0020	.9954	.9987	9.954
XXIV	1.0054	1.0011	.9988	1.0016	.9958	.9987	9.968
L.M.P.	1.0070	1.0013	.9975	1.0018	.9960	.9989	10.007
Average.	.9997	1.0029	1.0051	1.0026	.9939	.9983	9.946
No. of } days }	121	143	131	395	399	794	1758

AIR TIDE FEATURES.

There is a remarkable difference between the runs of the numbers in the different columns :

(A) The seventh column (perigee and apogee together) shows principal maxima at lunar noon and near lunar midnight, a secondary maximum at moonrise replacing the moonrise minimum, and a definite minimum near moonset. There is, moreover, on the whole a definite fall of pressure from beginning to end of the lunar day. The range is $\cdot 003$ inch.

(B) The mean perigee curve has its principal maxima before noon and after midnight, a secondary maximum at moonrise, and a curious asperity at XXIII. The general fall of pressure during the lunar day is pronounced. The range is nearly $\cdot 005$ inch.

(C) On the other hand, the apogee curve shows on the whole a small general rise, with maxima a little after lunar noon and perhaps before lunar midnight. It has the asperity at XXIII, and some tendency to a secondary maximum at moonrise, neither very definite. The range is about $\cdot 004$ inch.

(D) The noon perigee curve shows a large general rise during the lunar day, with principal maxima after noon and after midnight. The secondary maximum at moonrise is plainly visible, and there are also signs of the asperity at XXIII. The range between moonrise and U.M.P. is about $\cdot 007$ inch, that from moonset to L.M.P. about $\cdot 008$ inch.

(E) The midnight perigee curve shows a general fall during the lunar day, with maxima before noon and after midnight. The moonrise maximum is large and falls a little early. The asperity at XXIII is also large. The range is perhaps $\cdot 003$ inch.

(F) Almost the only prominent characteristic of the horizon perigee curve is the large general fall during the course of the lunar day. The maximum at moonrise is as large as it is on the noon and midnight curves, but the U.M.P. and L.M.P. maxima and the moonset minimum are almost evanescent, and the tidal effect consequently almost lost.

(G) The small asperities—namely, that at XX on the noon perigee curve, at XIX on the midnight perigee one, and at XVIII on the horizon perigee one—are possibly accidental, and only the first of the three is reflected in the mean perigee curve. There is, however, an analogue at XXI on the mean apogee curve. These asperities may have some resemblance to the moonrise maximum.

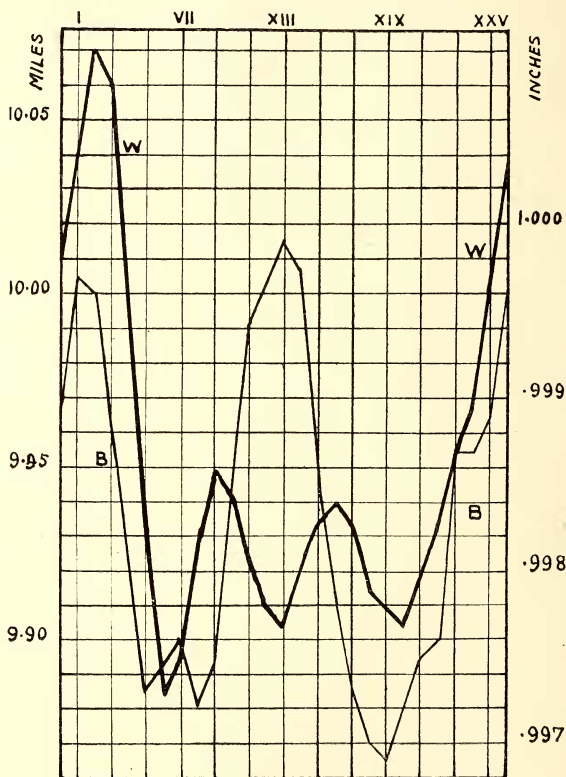
The displacement of the U.M.P. maximum forwards and backwards in time on the various curves is evidently largely a result of the general rise or fall of pressure level during the lunar day.

WIND ANALOGUES.*

(a) A comparison between columns 7 and 8 is shown in the open-

* See the second and third papers.

scale diagram. Both curves agree in the main, but with two important exceptions: First, that the moon-rise maximum of pressure is not reflected in the wind curve; and next, that the wind velocity reverses to a minimum



Air pressure (B) and wind velocity (W) during the lunar day.

at U.M.P. Both curves end the day at a lower level than they began it, and both show a small irregularity at XXIII. It is evident, as pointed out in the previous papers, that the lunar influence upon the velocity of the wind cannot be exerted in a simple way through the medium of the air-tide,

The whole range of velocity is nearly 0.2 mile an hour, its relation to the whole range of pressure being 62 miles to 1 inch.

(b) The results of the previous paragraph are emphasised in a comparison between the mean perigee curves of wind and pressure; and, besides, the XXIII asperity is strongly marked on the wind curve.

(c) Just as the moon-rise maximum and the asperity at XXIII are faintly marked on the pressure curve at apogee, so are the moon-rise minimum and the asperity of velocity. The turning-points on the apogee wind curve lag somewhat.

(d) The noon perigee curve of velocity also shows a large general rise. The smoothing of the curve, however, has intruded a fall after XXIII. Had this been done with the pressure curve the values at XXIV and XXV would have been 1.0027 and .9998 instead of 1.0354 and 1.0070 respectively, and the asperity at XXIII would have been merged into the L.M.P. maximum, as it is in the case of the wind.

(e) The slackening of velocity after the moon has crossed the meridian during midnight perigee corresponds to the large fall of pressure. The break in the fall of pressure at moonset which carries the minimum on to between XX and XXI is matched by the irregularity of velocity between XIX and XXI.

(f) At "horizon" perigee the large general fall of velocity is marked, and it enhances the moonset minimum. The wind curve bears the same kind of relationship to the pressure curve in this case as it does in general.*

(g) The small asperities of pressure in the nature of tiny maxima occurring near moonset are not represented in the velocities.

Note.—In the diagram the ordinates of the pressure curve are taken at clock hours, those of the wind apply to the middle of whole hours.

THE TROPICAL MONTH.

As a matter of interest rather than in the expectation of obtaining any important relationships, the mean daily velocities have been compared with the mean daily pressures during 255 tropical months. The results, smoothed in threes, are shown in Table II, in which column 2 gives for periods of twenty-seven days (of which the fourteenth day is that of the moon's greatest south declination) the mean barometric pressure of each day in inches, and column 3 the corresponding mean daily velocity of the wind.

* Better analogies would probably be obtained from a comparison of (e) and (f) if each of the curves were to be subdivided into two, one giving particulars for the hours between II and X, and the other for the hours between XIV and XXII. A longer series of observations would be required for the discussion however.

TABLE II.—*Mean Daily Pressure and Air Movement during the Tropical Month.*

Day.	Pressure (inches).	Velocity (miles a day).
1	26·125	125
2	26·126	125
3	26·128	124
4	26·130	126
5	26·133	128
6	26·136	128
7	26·135	126
8	26·134	125
9	26·132	125
10	26·131	125
11	26·131	125
12	26·132	126
13	26·132	127
14	26·135	126
15	26·138	123
16	26·139	123
17	26·135	124
18	26·132	124
19	26·130	124
20	26·133	122
21	26·136	121
22	26·137	121
23	26·135	121
24	26·134	121
25	26·134	121
26	26·131	122
27	26·125	123
Month	26·132	124

The barometric curve has three crests, the principal one falling about two days later than the day of the moon's greatest south declination, the two others (which are almost as great) coinciding with the moon's passage north or south of a parallel lying a little north of the equator. The total range of pressure in the month is ·014 inch in smoothed values and ·019 in unsmoothed. The equatorial crests rise ·004 inch above the mean line. Pressure when the moon is going north exceeds that when it is going south by about ·003 inch.

Quite a hundred years of observation would be necessary to give equally trustworthy wind values, but three crests seem also to be indicated,

diminishing in magnitude and falling progressively earlier, counting from greatest north declination, than the pressure crests. In general the velocity is two miles a day above the mean when the moon is coming south, and two miles a day below the mean for the rest of the time. If there be a tidal connection between the pressure and the velocity of the air during the tropical month, it cannot be a very direct one.

Luke Howard devoted a good part of his time to an attempt to connect the moon's motions with changes of atmospheric pressure. By dividing the days of the year, for twenty-seven years, into periods of about seven days each,

“the middle day of each week corresponding (1) with the moon's position coming north from the equator; (2) with her position in full north declination; (3) with her position returning to south over the equator; (4) with her full south declination,”

he obtained the following averages by means of a “clock barometer”:

N.		29·782 inches
Equator		29·777 „
S.		29·774 „
Equator		29·792 „

Howard's interpretation of these numbers was that—

“the barometric mean in our climate (England) is depressed (on an average of years) by the moon's position in south declination. . . . We have here, I think, evidence of a great tidal wave or swell in the atmosphere, caused by the moon's attraction, preceding her in her approach to us, and following slowly as she departs from these latitudes.”*

* Papers on Meteorology, 1854.